DEPARTMENT OF THE ARMY
HEADQUARTERS, UNITED STATES ARMY ALASKA
Fort Richardson, Alaska 99505-5000

United States Army Alaska Pamphlet 750-1 14 February 2006

# Maintenance of Supplies and Equipment
# Ground Vehicle Cold Weather Operation and Maintenance

**Summary.** This pamphlet concerning ground vehicle cold weather operation and maintenance has been revised. This pamphlet provides general information and technical guidance for operating and maintaining ground vehicles in cold weather.

**Applicability.** This pamphlet applies to USARAK units and activities and all other activities, organizations, and agencies located at or in the geographical areas of Forts Richardson, Wainwright, and Greely.

**Supplementation.** Supplementation of this pamphlet is prohibited without prior approval from the USARAK G-4, Attention: APVR-RDL.

**Interim changes.** Interim changes to this pamphlet are not official unless they are authenticated by the Director of Information Management. Users will destroy interim changes on their expiration date unless sooner superseded or rescinded.

**Suggested improvements.** The proponent agency for this pamphlet is the USARAK G-4 Maintenance Branch. Users are invited to send comments and suggested improvements on Department of the Army (DA) Form 2028 (Recommended Changes to Publications and Blank Forms) directly to APVR-RDL.

## Contents



*This pamphlet supersedes USARAK Pamphlet 750-1 dated 30 November 1996.

# Chapter 1
# Introduction

## 1-1. Purpose

a. This publication provides general information and technical guidance for operating and maintaining ground vehicles in cold weather. Primarily designed for use by vehicle maintainers, operators, and first line supervisors, this pamphlet places special emphasis on procedures and techniques used when working in subzero temperatures. Additionally, cold weather operation planners can use this pamphlet as a quick reference publication.

b. In addition to limiting training event scope and accomplishment, failure to follow this guidance may cause personnel injury and equipment damage. USARAK units should incorporate this guidance into their operation and maintenance Standing Operating Procedures (SOP).

c. This pamphlet does not replace applicable Technical Manuals (TMs), regulations, or Field Manuals (FMs). It is intended as an overview of the special and unique difficulties encountered in cold weather operations and maintenance. Refer to the appropriate operator or higher level manual for specific instructions.

## 1-2. References

a. Required publication.

None

b. Related publications. (A related publication is merely a source of additional information. The user does not have to read it to understand this pamphlet.)

(1) Center for Army Lessons Learned: http:/www./call.army.mil/.

(2) FM 9-207 (Operation and Maintenance of Ordnance Materiel in Cold Weather (0 Degrees F to Minus 65 Degrees F).

(3) Technical Bulletin (TB) 43-PS-323/-371/-395/-419/-443/-482/-491/-516/-517/-526/-576/-596/-601 (Preventive Maintenance Monthly).

(4) TM 9-6140-200-14 (Operator's, Unit, Direct Support, and General Support Maintenance Manual for Lead-Acid Storage Battery, 4HN, 24 Volt (NSN 6140-00-059-3528) M575047-1; 2HN, 12 Volt (6140-00-057-2553) M535000-1; 6TL, 12 Volt (6140-01-431-1172) M552149-1).

(5) Training Video Tape (TVT) 9-199 PIN #708347DA (Preparation of Wheeled Vehicles for Deployment to the Severe Cold Weather Battlefield).

(6) USARAK Regulation 750-4 (Lubricants, Fuels, Fuel Additives, and Fluids for Ground Equipment).

c. Referenced form. DA Form 2028 (Recommended Changes to Publications and Blank Forms). Cited in the suggested improvements statement.

## 1-3. Explanation of abbreviations

a. +.....Plus

b. - .....Minus

c. DA .....Department of the Army

d. FM.....Field Manual

e. LO .....Lube Order

f. OEA .....Oil, engine arctic

g. PMCS .....Preventive Maintenance Checks and Services

h. RPM.....Revolutions per minute

i. SUSV .....Small Unit Support Vehicle

j. TB .....Technical Bulletin

k. TM.....Technical Manual

l. TVT .....Training video tape

m. USARAK.....United States Army Alaska

**1-4. Responsibilities**

a. The Chief, USARAK G-4 Maintenance Branch, and USARAK Plans and Operations will monitor USARAK operations and maintenance in cold weather. Revisions to this pamphlet will include lessons learned

b. Units—

(1) Will review this pamphlet and incorporate applicable requirements and procedures into their unit standing operating procedures (SOP).

(2) Will insure copies of this pamphlet are made available in sufficient quantities to vehicle operators, maintainers, and first line supervisors.

(3) Should use this pamphlet to prepare and conduct annual cold weather operations training each October in preparation for arctic winter operations. Appendix A lists minimum training subjects.

## Chapter 2
## Cold Weather Effects and Operational Problems

### 2-1. General

The publication listed in the reference section and actual Soldiers' experiences of those who participated in cold weather exercises in the Alaska interior provided the consolidated information in this pamphlet. Conducted under some of the most extreme winter conditions the United States Army has ever encountered, Exercise Brim Frost 89 is the most noteworthy. During Brim Frost 89, ambient temperatures reached record lows in the Alaskan interior of down to minus (-) 77 degrees Fahrenheit.

### 2-2. Personnel

Self-preservation expends a large portion of every Soldier's time and energy in cold weather areas. This reduces personnel efficiency in materiel operation and maintenance. Besides operating and maintaining equipment, Soldiers must learn what is appropriate and how to improvise when operating in an arctic environment. As the temperature falls, all tasks, however routine they may seem, will range from difficult to complete to maximum-effort-required. It cannot be overstated that at temperatures below -50 degrees Fahrenheit, simple tasks require maximum effort of well-trained personnel on completely winterized equipment.

### 2-3. Cold weather materiel utility

Before acquisition, much of the Army's equipment undergoes testing for proper operation at temperatures down to -25 degrees Fahrenheit. Almost all equipment procured by the Army functions correctly at the -25 degrees Fahrenheit threshold. However, at temperatures below -30 degrees Fahrenheit, equipment begins to malfunction. Fall in temperature directly relates to decline in materiel performance. Appropriate TMs outline special operating procedures for extreme cold temperature operations. Failure to follow these special procedures and to properly operate and maintain equipment to -10/20 TM standards has resulted in many pieces of equipment failing in the field.

a. Cold weather effects on parts. Since all metals contract at lower temperatures and expand as temperatures increase, variant clearances may result in either binding or excessive clearances.

b. Servicing materiel. Before operating equipment, crews should review appropriate operator's manuals for cold weather operations. All operator's manuals include a section subtitled "Operations Under Unusual Conditions (Cold)."

(1) Soldiers must always maintain materiel in the best mechanical condition to withstand the added difficulties and prevent failures in subzero operation. Commanders must place special emphasis on maintenance inspections.

(2) Soldiers must carefully service various materiel components before, during, and after each operating period according to the pertinent TM. They must promptly report all failures and repair them. Failure to give this extra service and maintenance will result in actual damage, lost time, unwarranted expense, and improper functioning.

(3) Refer to pertinent operator and unit maintenance TMs for operation, lubrication, preventive maintenance checks and services (PMCS), and maintenance under unusual conditions.

(4) Operators must be very cautious when using materiel that has been inactive for a long time. Lubricants congealing in various components that could result in parts failing is of primary concern.

### 2-4. Cold effects on materials

a. Metals. Metals become brittle in severe cold temperatures and parts cannot withstand the same shock loads that they sustain at higher temperatures. At -20 degrees Fahrenheit certain steels can only withstand 50 percent of the shock load that they can withstand at room temperature. For a given change in temperature, various metals will expand or contract different amounts. These characteristics will especially affect bearings in which the bearing and shaft are of different metals, parts of different type metals bolted together, and meshing gears of different metals. Take special care in adjusting these types of parts for cold weather operations, especially when adjusting bearing clearances.

b. Rubber. Besides natural and synthetic rubber, there are hundreds of rubber substitutes. These synthetic rubbers look and usually react like natural rubber, although most of them do not attain a greater flexibility at high temperatures. However, as it cools, natural rubber will gradually stiffen, although it retains a large part of its elasticity until temperatures below -20 degrees Fahrenheit are reached. Below -20 degrees Fahrenheit certain peculiarities are observed. When cooled gradually but continuously over a short time, the rubber will remain flexible until reaching approximate -60 degrees Fahrenheit. Then the rubber suddenly loses its elasticity and becomes brittle. Furthermore, if the rubber is consistently kept at a temperature below -20 degrees Fahrenheit for a long time, even though it does not approach lower temperatures, an effect similar to crystallization occurs, causing it to become brittle.

c. Rubber covered cables. Take extreme care in handling cables at low temperatures. If the rubber jackets become hard, protect the cables from shock loads and bending to prevent short circuits caused by any covering breaks. Neoprene jackets on cables become very brittle and break readily at low temperatures.

d. Tires. Tires become rigid in the cold, causing flat spots on the portions that touch the ground during shutdown periods. Sidewalls become brittle and crack in severe cold temperatures. Inflate tires to appropriate pressure in cold temperatures. A tire inflated to 40 pounds per square inch indoors will change to 25 pounds per square inch when moved outside at -50 degrees Fahrenheit. Generally, inflate room temperature tires to 10 pounds per square inch over the normal winter operation pressure. Some vehicles are equipped with a Central Tire Inflation System (CTIS). CTIS allows the tires to be inflated or deflated while the vehicle is in operation. Extreme cold weather affects the CTIS seals ability to hold air pressure. Operators need to reference the appropriate TM for cold weather operation of CTIS. (Example) Disabling the CTIS then driving the vehicle long enough to warm the seals, then restarting the CTIS.

e. Plastics. Generally, plastics expand and contract much more than metal or glass. Handle any plastic parts or materials carefully. Many vehicular canvas covers have plastic windows that become very brittle and, in many cases, break due to a combination of cold and vibrations.

f. Glass. If handled carefully, expect glass, porcelain, and other ceramics to perform normally at low temperatures. If applying heat directly to cold windshields or vehicle glass, cracking may result.

g. Fabrics. Kept dry, fabrics generally retain their flexibility even at extremely low temperatures. However, tarpaulins present difficulties in conforming to their intended dimensions due to shrinkage. This is usually the result of wrinkles that are extremely difficult to smooth out at subzero temperatures. Whenever possible, unfold tarpaulins in heated enclosures.

h. Liquids. Place special training and emphasis on keeping water and other liquids in a liquid state. Items susceptible to freezing temperatures, such as batteries and petroleum, oils, and lubricants, must have warm storage and thawing equipment available.

i. Batteries.

(1) Vehicle batteries. Vehicle batteries lose their effectiveness during cold weather operations and can freeze if not kept fully charged. Table 2-1 shows how much of a battery's power is lost as the temperature drops. At room temperature, a fully charged battery is said to be 100 percent efficient.

**Table 2-1**
**Battery efficiency**

| Efficiency Percent | Temperature |
|---|---|
| 100% | Room Temperature |
| 50% | 15 Degrees Fahrenheit |
| 30% | -20 Degrees Fahrenheit |
| 10% | -30 Degrees Fahrenheit |

(2) The Army has started to use Absorbent Glass Matt (AGM) batteries. The AGM battery holds the electrolyte like a sponge. The Battery will not leak if tipped over or cracked. AGM batteries offer higher cranking power, more usable reserve capacity, and faster recharge. AGM batteries require a special charger. A pulse charger is required to pulse clean the battery internally and to apply correct voltage to prevent boiling the battery.

(3) Small equipment batteries. For small equipment, alkaline batteries are far superior to carbon batteries. For example, a flashlight using “D” batteries should use the BA3030/U rather than the BA-30. Also use these batteries in artillery and mortar night aiming post lights and tactical telephones such as the TA 312/PT.

(4) Lithium sulfur dioxide batteries. The lithium sulfur dioxide battery is recommended for use in extreme cold conditions. Lithium sulfur dioxide batteries have unique characteristics that provide improved operational capabilities and extended battery life. Handle lithium sulfur dioxide batteries as hazardous material when new and during use, and disposed of them as hazardous waste when depleted. Contact the unit hazardous waste coordinator or environmental compliance officer for proper disposal procedures.

## 2-5. Maintenance planning

Impress maintenance importance, especially PMCS, on all Soldiers operating in the arctic. Consider the man-hour increase for all tasks when planning and executing arctic operations. At temperatures below -20 degrees Fahrenheit, maintenance requires up to five times the normal amount of time. Complete equipment winterization, diligent maintenance, and well-trained crews are the keys to effective cold weather operations. Several areas that affect maintenance directly and require detailed planning are:

a. Shelter for materiel requiring maintenance.

b. Adequate portable heaters.

c. Proper clothing and tools for mechanics and drivers.

d. Sufficient lighting for maintenance operations.

e. Suitable methods for antifreeze, fuel, hydraulic fluid, and lubricant storage and issue.

f. Sufficient repair part supplies.

g. Sufficient snow and ice removal equipment.

## 2-6. Maintenance facilities, personnel, and equipment

a. Buildings and shelters. Provide heated buildings or shelters for cold weather maintenance. Proper and satisfactory servicing is difficult unless personnel are working in reasonably comfortable

temperatures. Maintenance of many components requires careful and precise servicing. Without heater usage, the increase in maintenance man-hours will be 25 to 200 percent above normal. Warmed by portable heaters or tent stoves, maintenance tents can serve as temporary expedient shelters.

b. Maintenance personnel.

(1) In cold weather operations, a highly organized, more intensive effort is required from all personnel. Providing heated buildings or shelters for maintenance operations will increase work efficiency and morale.

(2) Handwear may become saturated with fluids when performing maintenance on fuel or cooling systems. This reduces the handwear's insulating value and may result in a cold injury. To prevent this, it is advisable to wear rubber gloves under the handwear, preventing fluids from contacting the skin. Never allow unprotected hands to come in contact with cold metal.

(3) Personnel should avoid leaning on cold-soaked equipment or kneeling and lying on the ground. Rapid body cooling caused by heat transfer to the equipment or ground may result in cold injury. Mechanics should place insulating material, such as fiber packaging material, corrugated cardboard, rags, or tarpaulins between them and the cold-soaked equipment.

(4) Place a box, pan, or canvas under the vehicle to catch dropped parts. This prevents the parts from becoming lost in the snow.

c. Lighting equipment. Provide sufficient light to conduct maintenance operations. Lights with ample cable extensions, attachment plugs, connectors, and spare bulbs are essential.

## Chapter 3
## Winterization Equipment

### 3-1. General

Vehicles required to operate under arctic conditions have installed winterization equipment designed to assist the vehicle in starting, operating, and producing adequate cabin heat.

### 3-2. Heaters

a. Personnel heaters. Generally, vehicles provide adequate heat through personnel hot water heaters. Hot water heater operation is insufficient when ambient temperatures drop below -25 degrees Fahrenheit. In USARAK, fuel burning heaters have replaced hot water heaters in most tactical vehicles except small unit support vehicles (SUSVs) and some engineer equipment. Per MIL-STD-1472C, military vehicle personnel heaters must maintain a plus (+) 41 degrees Fahrenheit temperature. The fuel burning heaters often fail because of—

(1) Contaminated fuel.

(2) Low fuel level.

(3) Low voltage available for operation.

(4) Inexperienced operators or mechanics.

(5) Heater design characteristics.

b. Proper engine preheating is critical during cold weather starting. Engines, starters, and other components may receive extensive damage if not properly preheated. Engines with correct oil and lubricants will, generally, start down to -25 degrees Fahrenheit without preheating. However, to reduce engine wear and damage, it is advisable to preheat engines at temperatures below -10 degrees Fahrenheit.

c. Power plant and standby heater systems.

(1) Standby heaters. Most vehicles are equipped with a fuel-fired engine coolant preheater to maintain engine heat for starting ease. Fuel fired engine coolant heaters are an efficient way to preheat engines for starting in cold weather. They have a low electrical requirement (usually about 2 amps) and are fuel efficient. This reduces fuel consumption, noise, exhaust emissions, and wear on the engine from idling in cold weather. Take care when using this system since repeated or excessive use could drain the vehicle's batteries.

(2) Engine block heaters. Most USARAK wheeled vehicles, and commercial construction equipment have these heaters installed. The block heater warms engine coolant, which, in turn, warms the engine's block for starting ease. This system requires a 120-volt alternating current power source. On some equipment, coolant routed through a hollow plate on which the battery sits warms the battery.

(3) Optional equipment. Some units use battery pads, battery maintainers, and blankets, engine perk heaters, and oil pan heating pads.

(4) Extension cords. When using 120-volt alternating current power, extension cords are required. Units should use only arctic extension cords (that remain flexible in extreme cold) with at least 14 gauge wiring.

(5) Battery Maintainers. If the vehicles are equipped with a Quick Charge 6 amp, 24 volt battery maintainer they will charge and maintain the battery when plugged into the head bolt plugs.

d. Personnel carrier arctic kits. Many USARAK 2 ½ & 5-ton trucks and 2- or 4-door high mobility multipurpose wheeled vehicles are fitted with kits that provide improved cabin area sheltering and insulation.

# Chapter 4
# Operation Preparation

## 4-1. General

TMs provide complete PMCS procedures and must be on hand for operator maintenance activities. This chapter addresses items requiring special attention.

## 4-2. Lubricants

Applicable lubrication orders and/or TMs specify lubrication required for Army equipment. USARAK supplements to these publications through coordination with Army technical activities. Supplementation allows USARAK to survive arctic conditions while also maintaining the capability to deploy anywhere in the world without first having to change lubricants. Lubrication order and TM supplementation for ground equipment is contained in USARAK Regulation 750-4 and is applicable to all USARAK units and activities.

## 4-3. Chassis and body components

a. Air brakes.

(1) Frozen moisture in the air brake system seriously affects operation. Brake lines, air brake filters, brake chambers, push rods, valves, and seals are subject to defects and failure in the cold. Condensation between brake shoes and drums may freeze, making it impossible for the vehicle to move. When this happens, use portable heating equipment to thaw the brake shoes from the drums.

(2) Most vehicles with an air brake system now use an air dryer. These systems should be drained and serviced according to the appropriate TM.

(3) Ensure the alcohol evaporator kit is functioning if it is part of the system. Check the air compressor, the unloader valve, and the governor for good condition and satisfactory operation. With air pressure at the governed maximum and brakes applied, stop the engine. There should not be a noticeable drop in pressure within 1 minute. Drain reservoirs immediately after operation and close drain cocks immediately after draining to prevent freezing in the open position. Build up brake pressure before the moving the vehicle again. Release the brakes to prevent the brake shoes from freezing to the drums.

b. Shock absorbers. The light weight hydraulic oil in shock absorbers is susceptible to extreme cold weather. Check shocks for leaks and breakage at every rest period. After long inactivity periods, move the vehicle out slowly to allow the hydraulic oil to warm up. This helps prevent leakage and provides a smoother ride.

c. Steering gear and hydraulic pumps.

(1) Use 0W-30 oil, engine arctic (OEA) in power steering gear boxes and hydraulic pumps year round.

(2) Warm up steering systems before movement (especially power steering systems). While then engine is warming up, move the steering wheel SLOWLY lock to lock. Repeat this a few times to warm the steering system oil. The heat created by the pump’s high pressure side will quickly warm the oil to an acceptable operating temperature. In manual steering systems, this exercise will achieve the same results except it will take more time due to lower friction inherent in non-pressurized manual systems.

(3) Examine the arms, tie rods, drag links, seals and boots, pitman arm, gear column, and wheels for good condition and secure mounting. Ensure that the gear case is not leaking and the gears are properly adjusted. Use the correct lubricating oils cited in appropriate LO to fill gear cases.

d. Small Unit Support Vehicle track. Remove all dirt, snow, and ice and inspect for good condition and proper lubrication. Check the track adjustment. Do not adjust tracks too tightly in a warm shelter since they will contract and break easily in temperatures below -40 degrees Fahrenheit.

e. Tires. At -50 degrees Fahrenheit, tires become very brittle and sidewalls may contract and separate from wheels. Though they appear to be all right, the tire can slip away from the wheel and tear the tubes and valve stems. With tubeless tires, this slippage can break the seal between the tire and wheel, deflating the tire. The key here is to move very SLOWLY for the first mile or so, allowing the tires to warm up and become pliable, giving a good seal against the wheel.

f. Springs. Metal, like most other material, becomes brittle in extreme cold weather. Cold-soaked metal can easily snap, causing damage to vehicle and trailer suspension systems. By moving out SLOWLY, the springs will warm up and regain their elasticity, avoiding damage.

g. Wheel bearings. Inspect bearings for looseness and proper adjustment. No lubricant changes are required since all wheel bearings are serviced for year-round operations with grease (automotive and artillery) that has a temperature range of -65 to +225 degrees Fahrenheit.

h. Fire extinguishers. Winterize all carbon-dioxide fire extinguishers per the appropriate fire extinguisher technical bulletin.

**4-4. Power train**

a. Engine lubrication system. At cold temperatures, higher weight engine oils increase the oil’s fluid friction on cylinder walls and bearings so much that it is not possible to crank the engine with the vehicle's battery. Using 0W-30 (OEA) synthetic oil will significantly reduce fluid friction while providing adequate lubrication during starting. If vehicles are under warranty you must use the specific lubricants called for by the manufacturer

b. Transmissions. Automatic, semi-automatic, and D5 tractor transmissions will use 0W-30 OEA. Manual transmissions will use 75W gear oil year-round.

c. Cooling system. Year-round, fill radiators in all wheeled vehicles with an approximate mix of three parts antifreeze (ethylene glycol, inhibited (MIL-A-46153)) to two parts water. This 3:2 ratio will provide antifreeze protection down to approximately -60 degrees Fahrenheit. Test all antifreeze quarterly with a hydrometer or view type tester. Record the cooling system’s condition and freeze protection degree in the Army Maintenance Management System records. Refer to table 4-1 for antifreeze requirements for protection.

d. Universal and slip joints. Thoroughly lubricate joints according to the vehicle LO.

**Table 4-1**

**Antifreeze protection table**

**Penray Coolant Chart for Maintaining 50% Antifreeze**

Freeze Point (deg. F) Vs. Percent Antifreeze

Temperatures (+32° F to -5° F)

| System Cap. (Gal) | +32 / 0% | +25 / 10% | +20 / 15% | +15 / 20% | +10 / 25% | +5 / 30% | -5 / 35% | -12 / 40% | -23 / 45% | -34 / 50% | -50 / 55% | -65 / 60% | -75 / 65% | -84 / 70% | -70 / 75% | -55 / 80% | -43 / 85% | -30 / 90% | -5 / 100% | System Cap. (Gal) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Drain Coolant and Add Antifreeze (Quarts) | | | | | | | | | | Drain Coolant and Add Water (Quarts) | | | | | | | | | |
| 5 | 10 | 9 | 8 | 8 | 7 | 6 | 4 | 3 | 2 | 0 | 2 | 3 | 4 | 6 | 7 | 8 | 8 | 9 | 10 | 5 |
| 6 | 12 | 11 | 10 | 9 | 8 | 7 | 5 | 4 | 2 | 0 | 2 | 4 | 5 | 7 | 8 | 9 | 10 | 11 | 12 | 6 |
| 7 | 14 | 12 | 11 | 11 | 9 | 8 | 6 | 5 | 2 | 0 | 2 | 5 | 6 | 8 | 9 | 11 | 11 | 12 | 14 | 7 |
| 8 | 16 | 14 | 13 | 12 | 11 | 9 | 7 | 5 | 2 | 0 | 2 | 5 | 7 | 9 | 11 | 12 | 13 | 14 | 15 | 8 |
| 9 | 18 | 16 | 15 | 14 | 12 | 10 | 8 | 6 | 3 | 0 | 3 | 6 | 8 | 10 | 12 | 14 | 15 | 16 | 18 | 9 |
| 10 | 20 | 18 | 17 | 15 | 13 | 11 | 9 | 7 | 3 | 0 | 3 | 7 | 9 | 11 | 13 | 15 | 17 | 18 | 20 | 10 |
| 11 | 22 | 20 | 19 | 17 | 15 | 13 | 9 | 7 | 3 | 0 | 3 | 7 | 9 | 13 | 15 | 17 | 19 | 20 | 22 | 11 |
| 12 | 24 | 22 | 20 | 18 | 16 | 14 | 11 | 8 | 4 | 0 | 4 | 8 | 11 | 14 | 16 | 18 | 20 | 22 | 24 | 12 |
| 13 | 26 | 23 | 22 | 20 | 17 | 15 | 12 | 9 | 4 | 0 | 4 | 9 | 12 | 15 | 17 | 20 | 22 | 23 | 25 | 13 |
| 14 | 28 | 25 | 23 | 22 | 19 | 16 | 13 | 9 | 4 | 0 | 4 | 9 | 13 | 16 | 19 | 22 | 23 | 25 | 28 | 14 |
| 15 | 30 | 27 | 24 | 23 | 20 | 17 | 14 | 10 | 5 | 0 | 5 | 10 | 14 | 17 | 20 | 23 | 24 | 27 | 30 | 15 |
| 16 | 32 | 28 | 26 | 24 | 21 | 18 | 15 | 11 | 5 | 0 | 5 | 11 | 15 | 18 | 21 | 24 | 26 | 28 | 32 | 16 |
| 17 | 34 | 30 | 28 | 26 | 23 | 19 | 15 | 11 | 6 | 0 | 6 | 11 | 15 | 19 | 23 | 26 | 28 | 30 | 34 | 17 |
| 18 | 36 | 32 | 30 | 27 | 24 | 21 | 17 | 12 | 6 | 0 | 6 | 12 | 17 | 21 | 24 | 27 | 30 | 32 | 35 | 18 |
| 19 | 38 | 34 | 32 | 29 | 26 | 22 | 18 | 13 | 7 | 0 | 7 | 13 | 18 | 22 | 26 | 29 | 32 | 34 | 38 | 19 |
| 20 | 40 | 36 | 33 | 30 | 27 | 23 | 18 | 13 | 7 | 0 | 7 | 13 | 18 | 23 | 27 | 30 | 33 | 36 | 40 | 20 |

If the reading on your refractometer does not appear on the chart, the solution is over-concentrated. Drain your system and start over by adding a 50/50 mix of Fleetcharge® or DDC PowerCool® Antifreeze and Water to your engine's system.

**Example, if the temperature for a 12 gallon system is -23° F, drain four quarts of coolant and add 4 quarts of pure antifreeze. Or, if the temperature for an 8 gallon system is -50° F, drain 2 quarts of coolant and add 2 quarts of water.*

## 4-5. Fuel system

a. Anti-icing additive. Condensation can easily build up in tanks, drums, containers, fuel pumps, and carburetors. At low temperatures, this condensation will form ice crystals that will clog injector nozzles, carburetor jets, fuel lines, filters, and pumps. Anti-icing additive usage will eliminate the condensation. When temperatures fall below +32 degrees Fahrenheit, use 1 pint icing inhibitor (MIL-I-27686) to every 40 gallons of diesel fuel.

b. Ether. Using ether or a similar product as a starting fluid is strictly prohibited, except when the equipment's original configuration includes such a system. Factory installed systems may be used.

**4-6. Electrical system**

One of the greatest hindrances to successful military operations in arctic conditions is the cold's effect on batteries. Extreme cold effects and lack of preventive maintenance result in a significant reduction in battery life expectancy.

a. Vehicle batteries.

(1) Periodically check lead acid battery's specific gravity during winter operations. Consider a 1.280 specific gravity electrolyte level the optimum level for a charged battery. Freezing can damage the battery. Slowly thaw frozen electrolyte. If after thawing, there is no apparent damage to the battery, attempt to recharge it.

(2) A battery will more readily accept a charge at warmer temperatures. If it is necessary to recharge a storage battery at low temperatures, the charging voltage should be low enough to prevent excessive electrolyte boiling.

(3) Do not add water to a battery at subzero temperatures. When it is this cold, the water will not mix with the electrolyte and it will freeze in the battery.

(4) Frozen batteries can either rupture internally or externally.

(a) External rupturing. Batteries that rupture externally spill poisonous sulfuric acid out into the environment. When this occurs, equipment damage and burned personnel may result. Constantly check batteries' conditions.

(b) Internal rupturing. Battery electrical circuitry may short-out internally, resulting in component damage and possibly fire.

(5) Vehicle batteries should be warmed to at least +35 degrees Fahrenheit before they will accept an adequate charge from an external source (alternator or generator).

b. Spark plugs. Clean spark plugs or replace them as necessary. Adjust gap 0.005 inch less than recommended by the applicable vehicle TM.

## Chapter 5
## Operation and Maintenance Procedures

### 5-1. General

a. At temperatures below -25 degrees Fahrenheit, operators may have to periodically start engines to warm them and recharge batteries. However, this may break noise discipline requirements. Preferably, units should use Swingfire or fuel fired coolant heaters or other systems available to warm engines before their use.

b. To keep equipment in a fully mission capable condition, commanders and maintenance personnel should develop a schedule that requires engines be started on a routine basis. A well-planned engine starting and warming schedule will help minimize time consuming slaving and recovery that detracts from other training events.

c. If vehicles are equipped with a fuel fired engine coolant preheater they do not need to be started to keep the engines warm. Use the fuel fired heater and monitor the battery condition.

d. Experience determines starting schedule intervals. Factors such as ambient or expected temperatures, vehicle condition, and readiness conditions also influence the starting schedule. Consider the following:

(1) Vehicles and other equipment should only be cold started using procedures outlined in appropriate TMs. Carefully read and follow the vehicle operating instructions for under unusual or arctic conditions (cold) found in the -10 series TM.

(2) Do not allow vehicles to become cold-soaked. Cold-soaking can occur at temperatures below -25 degrees Fahrenheit.

(3) Lubricants must be maintained in a fluid state to prevent equipment damage.

(4) Keep batteries warm and fully charged. If the Swingfire or fuel fired heater or battery blanket cannot keep the battery warm, consider removing the battery and placing it in a heated shelter.

(5) Noise discipline and concealment may have to be sacrificed to maintain vehicles' operational readiness.

### 5-2. Starting

a. For a successful start in cold weather, refer to cold weather/arctic starting procedures in the applicable TM, modified as necessary by the procedures in this chapter. When attempting the start, do not hold the key in the "start" position longer than 15 seconds. Allow 60 seconds for the starter to cool down between starting attempts.

b. Starting engine with a storage battery.

(1) Gasoline engines.

(a) Shut off electrical accessories before starting.

(b) Insure the engine is filled with 0W-30 (OEA) lubricant.

(c) The battery must be fully charged and sufficiently warm to supply enough current to crank the engine and to supply the necessary spark for ignition.

(2) Diesel engines. In addition to the items listed under gasoline engines, diesel engines may require air intake preheating. Do preheating as follows:

(a) Use manifold air heaters or fuel fired engine pre-heater usually installed on 2 1/2-ton and larger vehicles when the ambient temperature drops below +32 degrees Fahrenheit. Use this device only when the engine is turned over. Switch off the manifold air heater when the engine starts.

(b) Using auxiliary power for engine starting. Never attempt to slave start a vehicle in extreme cold weather without first checking the battery's electrolyte solution. The battery could explode if it contains frozen electrolyte. The vehicle's operators manual lists slave starting procedures. General procedures are:

(1) Start the vehicle engine supplying the auxiliary power and adjust the engine idling speed to 1200 revolutions per minute (RPM).

(2) Connect the slave cable to the auxiliary power receptacle in each vehicle. Connect the slave cable positive-to-positive and negative-to-negative. If the dead vehicle has a master switch, turn it off while connecting the slave cable.

(3) Turn on the master switch in the receiving vehicle.

(4) Start the dead engine and adjust the engine idling speed to slow.

(5) Disconnect the extension cable from both vehicles as soon as the receiving vehicle idles at 650 RPM without stalling.

(6) Increase the engine speed in the receiving vehicle to 1000 to 1200 RPM. Check the vehicle’s battery-generator indicator to insure that it shows the battery is being charged.

c. Towing to start engine. Tow a vehicle to start its engine only in an extreme emergency. Use a tow bar when towing. Do not tow-start vehicles with automatic transmissions. Consult the vehicle operator's manual for specific instruction, procedures, cautions, and limitations.

d. Jump starting procedure. Refer to figure 5-1 for a proper jump starting procedure illustration. To jump start a vehicle, insure that—

(1) Batteries are the same voltage.

(2) Both the negative posts are grounded.

(3) The electrolyte not frozen.

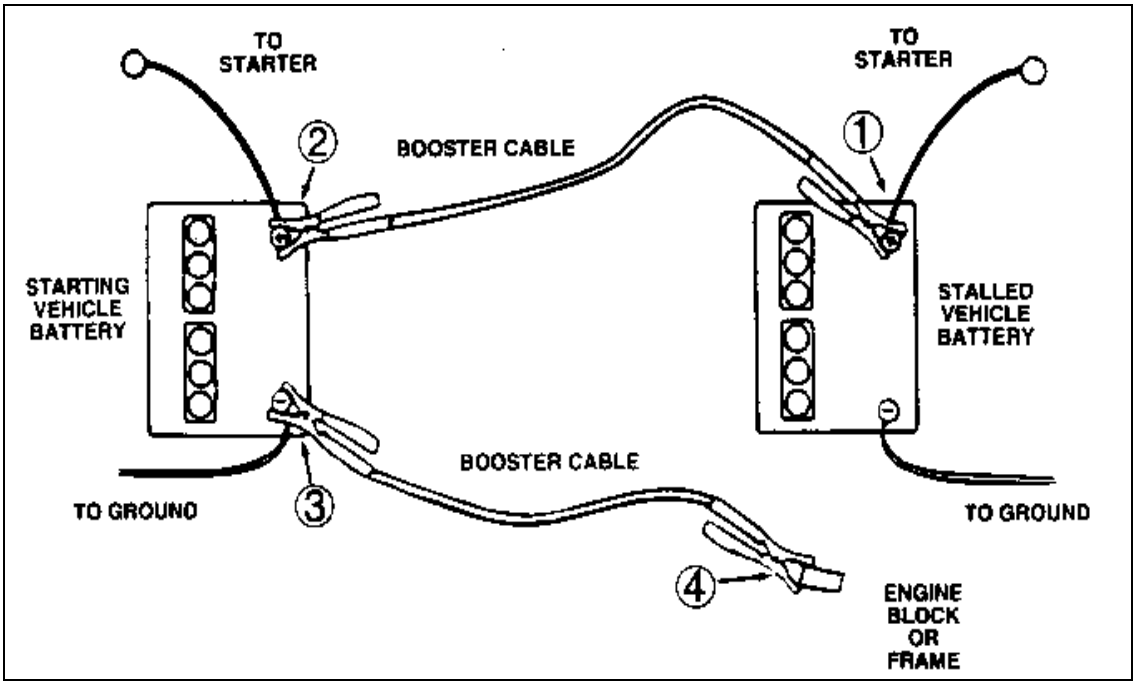
(4) The vehicles are not touching.

(5) Ignition and accessories are off, gears in park or neutral, and brakes on.

(6) Attach clamps in the order shown in figure 5-1. Remove clamps in reverse order.

**Figure 5-1. Proper jump start procedure**

# JUMP STARTING




## 5-3. Idling

a. Idling problems. Idling is a wasteful and hazardous practice. It has detrimental supply, tactical mission, and safety effects because—

(1) It increases fuel consumption.

(2) Done at low RPM, idling can discharge batteries because the alternator may not produce enough electricity to charge the battery. Turn off all nonessential electrical items to help prevent battery discharge.

(3) It dilutes crankcase oil, decreasing oil viscosity.

(4) It increases engine wear.

(5) It creates carbon monoxide hazards.

(6) It is detrimental to concealment and camouflage.

(7) It may cause engine overheating or failure if not supervised.

b. Successful idling rules.

(1) Do not idle engines indefinitely. Idle them only as long as needed to ensure lubricants stay warm.

(2) Do not operate personnel heaters when engine is at low idle. This reduces engine heat.

(3) Insure licensed personnel perform idling operations and are PHYSICALLY BEHIND THE WHEEL monitoring the temperature and pressure gauges while the equipment is running. Be sure there is adequate cabin area ventilation to prevent carbon monoxide poisoning.

(4) Idle engines at 1000 to 1200 RPM to circulate the antifreeze and keep batteries charged. This helps the engine maintain proper operating temperature.

**5-4. Chassis and body components**

a. General. Ice, mud, snow, and so forth can build up to such an extent on operating vehicles that it can overload vehicle components, reduce ground and other clearances, and prevent or interfere with normal moving component operation. Slush and water buildup and freezing around an operating vehicle's wheels can cause a steering ability loss.

b. Small Unit Support Vehicle (SUSV) track. Check oil-lubricated road wheel bearings to ensure that water has not collected during operation. If significant amounts have collected, seals may rupture as the water freezes and expands. If possible, avoid quick starts, stops, sharp turns, and side slippage on ice and snow, as they can throw tracks and/or cause loss of control. Keep in mind that as the track warms up under use, snow will melt. After parking the SUSV, water on the track will refreeze, resulting in the SUSV being frozen to the ground. To resolve this situation, use a portable hot air heater to melt away ice on the track. If time is critical, slowly move the vehicle back and forth in an attempt to break away from the frozen ground. Park the SUSV on tree branches or similar material to prevent its freezing to the ground.

c. Tires. If tires have a flat spot where they contacted the ground, use light pressure on the accelerator and drive the vehicle slowly until the generated heat permits tires to round out. Also, during freezing rain or sleet periods, move vehicle around often. To prevent tires from freezing to the surface, place small branches or other insulating material under them before parking. If tires do freeze in place, use a portable hot air heater to melt the tires loose.

d. Chains. Check vehicle chains to insure that they are serviceable before operation. Require drivers to practice mounting and removing them. Remove chains when not needed. This practice keeps chains in good condition; chains will wear out with approximately 2350 miles of asphalt road operation. Additionally, they can cause damage to vehicular and body suspension components.

e. Springs. When starting out, proceed with caution to allow the springs enough time to attain some flexibility. Avoid driving into depressions or over obstacles that may cause excessive flexing and possible spring breakage in extreme cold.

f. Cab enclosures. Employ heaters to maintain adequate temperatures within cab enclosures. When crossing frozen streams or other bodies of water, open the doors to permit quick personnel escape in case the vehicle should break through the ice.

g. Parking brakes. Do not park with the brakes set since they may freeze in this position and may not release. Use chock blocks to hold wheels or tracks in place. If the brake components do freeze in the set position, use an external heat source, such as a portable heater, for thawing, to prevent damage to the vehicle power train. For the SUSV, apply the parking brakes when stopped, since there is no neutral-park gear.

**5-5. Power train**

a. During operation. Driver's must be extremely careful when moving a vehicle with congealed gear case lubricants or wheel bearing greases and tires frozen to the ground. An attempt to operate with these conditions can damage the power train, the clutch facings, universal joints, or gear teeth. When moving a vehicle, put the transmission in low gear and the transfer unit, where applicable, in low range. Drive the

vehicle approximately 100 meters, being careful not to stall the engine, then upshift. Continue slowly into the higher gears until the vehicle moves freely and tire thump ceases.

b. After operation. When preparing a vehicle for shut down, place the transmission and transfer unit shift levers in the neutral position. This prepares the units for the next start by preventing then from freezing in an engaged position. On vehicles equipped with a turbo charged engine, the engine must be idled for 3 to 5 minutes to cool the turbo charger. Serious engine damage could result if not cooled properly.

**5-6. Engine lubrication system**

a. An engine's mechanical efficiency depends on proper lubrication system function. The driver's and unit mechanic's careful PMCS attention is required to keep the system in the best working condition. Check the engine oil level before starting and fill it to the prescribed level. As soon as an engine starts, check the oil pressure gauge readings. If the gauge does not indicate engine oil pressure within 30 seconds, shut down the engine and determine the cause. On vehicles equipped with warning lights, stop the engine and investigate the cause if the engine-oil pressure warning light does not go out within 30 seconds.

b. Low oil pressure warning lights may blink on and off idling at 500 to 650 RPM using 0W-30 lubricant, but it should not stay on at higher RPMs.

c. The two most common engine lubrication system failures are caused by low or no oil pressure and the sludge accumulation in the lubricating oil.

(1) Low or no oil pressure. Fuel-diluted oil, hot oil, or low viscosity oil normally cause low oil pressure. Cold, congealed, high-viscosity oil; a clogged strainer; a defective oil pump; lack of lubricant; or an engine component failure (such as an engine bearing) may cause no oil pressure. Do not overlook the possibility that the oil pressure gauge may be defective. If the oil pressure gauge is working accurately, the oil is up to the full mark, and the oil filter element is not clogged, the failure is probably in the pump or lines.

(2) Lubricating oil sludge accumulation. Cold weather tends to prevent engines from reaching normal operating temperatures, increases engine carbon development, and increases oil dilution and condensation. These factors all combine to create engine sludge. To correct a sludge condition, drain the oil while the engine is hot and refill with 0W-30 lubricant. After operation, inspect the oil pan, the valve cover, the timing chain/gear cover and gaskets, and the external oil lines for oil leaks and correct as necessary.

d. After each operating period, carefully inspect and service the lubrications system as necessary.

(1) Inspect the oil pan, the valve covers, the gaskets, and any external lubrication system units for leaks; correct the deficiencies or report them to maintenance personnel.

(2) Check the engine oil and fill it to the prescribed level.

**5-7. Electrical system**

a. Storage battery. The storage battery functions as the electrical system's heart, especially during the starting phase.

b. During operation. Allow the engine to warm up to the recommended temperature for subzero operation (thermostats open at approximately +180 degrees Fahrenheit). Check instrument operation during warm up, especially the oil pressure gauges and warning lights. Inspect fan belts before operation. Fan belts break at a much higher rate below -50 degrees Fahrenheit.

c. Maintenance.

(1) Place special emphasis on proper electrical system care to insure efficient operation. If it is necessary to recharge a storage battery under low-temperature conditions (electrolyte not frozen) the charging voltage should be low enough to prevent excessive electrolyte gassing or boiling. At low temperatures, the permissible charging current will be considerably less than at higher temperatures and will, therefore, require a proportionately longer charging time (see TM 9-6140-200-14).

(2) Thaw frozen batteries at room temperature before charging. Check the electrolyte level. It should not be above the level indicated on cell cover vent plug. Adding water (distilled only) to a battery when it is exposed to subzero temperatures and not being charged causes the water layer to stay at the top and freeze before it has a chance to mix with the electrolyte. Never attempt to recharge a battery with frozen electrolyte.

**5-8. Fuel system**

a. Precautions. Successful low temperature vehicle operation depends largely on the condition of the fuel used. Water in engine fuel can cause serious difficulties. Observe the following precautions:

(1) Wipe all snow from the dispensing equipment and around the fuel tank fill cap before removing the cap. After filling the tank, replace the cap securely.

(2) Always keep the fuel tank filled to proper markings. Refuel only to the expansion mark.

b. Maintenance.

(1) Inspect fuel filters for good condition and replace contaminated elements.

(2) Drain the fuel filters, where possible, at the end of each day’s operations. Do not assume that the filter is dry if nothing flows from the drain cock. If water is present, it could have frozen solid overnight.

(3) Observe whether the diesel-fuel nozzles and lines are in good condition.

(4) Observe whether the fuel gauge is operating and registers the amount of fuel in the tank.

**5-9. Cooling system**

a. Water pump. Check for leaks. Check the fan belt for cracks or separation according to the TM. When using a swingfire or auxillary coolant heater, failure to turn-on or ensure the auxiliary water circulation pump is running will most likely result in coolant hoses bursting.

b. After operation. Check the radiator after shutdown and engine has cooled to determine the coolant level. If the coolant level is low, add antifreeze to return the radiator to full level.

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## Appendix A
## Cold Weather Training Subjects

The minimum cold weather training subjects that should be included in annual training are shown below.

| Subject | Minutes | References |
|---|---|---|
| Introduction | 15 | Instructor Notes |
| Cold weather effects on equipment and operational problems | 45 | TVT 9-199 and FM 9-207 |
| Lubricants, Fuels, Fuel Additives And Fluids for Ground Equipment | 30 | USARAK Regulation 750-4 |
| Fuel system care and maintenance | 30 | FM 9-207 |
| Battery care and maintenance | 30 | TM 9-6140-200-14 |
| Cold weather starting, engine preheating, and Swingfire heater usage | 45 | TVT 9-230 and applicable |
| Operation of Personnel heater | 30 | Applicable vehicle TM |